

Hedging Liquidity Risk: *Potential Solutions for Hedge Funds*

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The era since the early 1970s might legitimately be termed as the Renaissance Period in finance. The classic work in option-pricing by Black and Scholes [1973], and Merton [1973] helped mitigate equity risk through the prudent use of equity options. In the past three decades, derivatives in interest rates, foreign exchange, weather, credit, and real estate have all grown in popularity. Each of these instruments allows for the isolation of an element of risk, and the transfer of this risk to a willing market participant. This certainly makes aggregate risk distribution more effective. By strategically conducting risk neutralization, a firm may concentrate on its core competency. Apart from market players who invoke hedging for risk management purposes, there are speculators who trade these derivatives in the belief that they have a particular insight on the direction of the underlying, as well as arbitrageurs who try to take advantage of pricing inconsistencies. This article introduces five new derivatives that allow for the reduction or elimination of liquidity risk—namely, withdrawal options, hedge fund return puts, hedge fund return swaps, hedge fund return swaption, and liquidity options.

LIQUIDITY IN THE HEDGE FUND INDUSTRY

At the current time, reducing liquidity risk is a key challenge that investors face in managing their hedge fund portfolios. With

increased regulatory pressure by the SEC, and an increasing commitment demanded by fund managers from their limited partners, investors face longer lock-up periods and corresponding higher liquidity risk. Further, as institutional investors, such as pension funds, continue to increase their allocations to hedge funds (assets reached \$71 billion in May 2005, up from \$29 billion in January 2000),¹ there is a growing realization of the need for derivative instruments that can effectively hedge liquidity risk.

The need for flexibility in this asset class has never been more important. The number of managers charging management fees in excess of 1% has grown to 53%, up from 41% at the end of 2005.² With these increased fee structures, as well as other significant barriers to entry, there is a growing demand among investors to help control the risks inherent in investing in hedge funds. In this article, we will focus on liquidity risk, an area that, in recent years, has received renewed interest from academics, practitioners, and investors. A more concrete application, as it relates to hedge funds, can be found in Derman [2006]. Derman calculates that the risk premium for a two-year lock up over a one-year lock up can be as much as 1%, and approaches a constant of 3% for longer lock ups.

TYPES OF LIQUIDITY RISK

Liquidity risk is the financial risk that arises from not being able to redeem one's

investment instantaneously at a fair price (i.e., not having perfect liquidity). It can have a powerful impact on the portfolio as witnessed by the 1993 Metallgesellschaft Debacle (Smithson [1998]) and the Long Term Capital Management (LTCM) blowup in 1998. LTCM had deliberately “traded” liquidity by buying illiquid, cheap Russian GKO bonds and hedging by shorting liquid, on-the-run bonds. With Russia defaulting, Russian bonds became more illiquid and decreased sharply, so the short position of the liquid bonds provided little hedge, since they remained mainly unchanged.

Liquidity risk is typically considered a type of market risk. In risk management practice, it is simply added to conventional VAR or more modern approaches.

As is common knowledge, value at risk (VaR) measures the maximum loss at a certain confidence level, for a certain time frame. Expected tail loss (ETL) attempts to quantify extreme losses, which VaR ignores. Spectral risk measures (SRM) explicitly relate the risk measure to a user’s risk-aversion function. ETLs and SRMs have the convenient property of subadditivity, which states that the sum of individual risk cannot be bigger than the aggregate risk. VaR does not necessarily satisfy subadditivity. Enterprise risk management (ERM) methods investigate a company holistically and address risk on an aggregate basis.

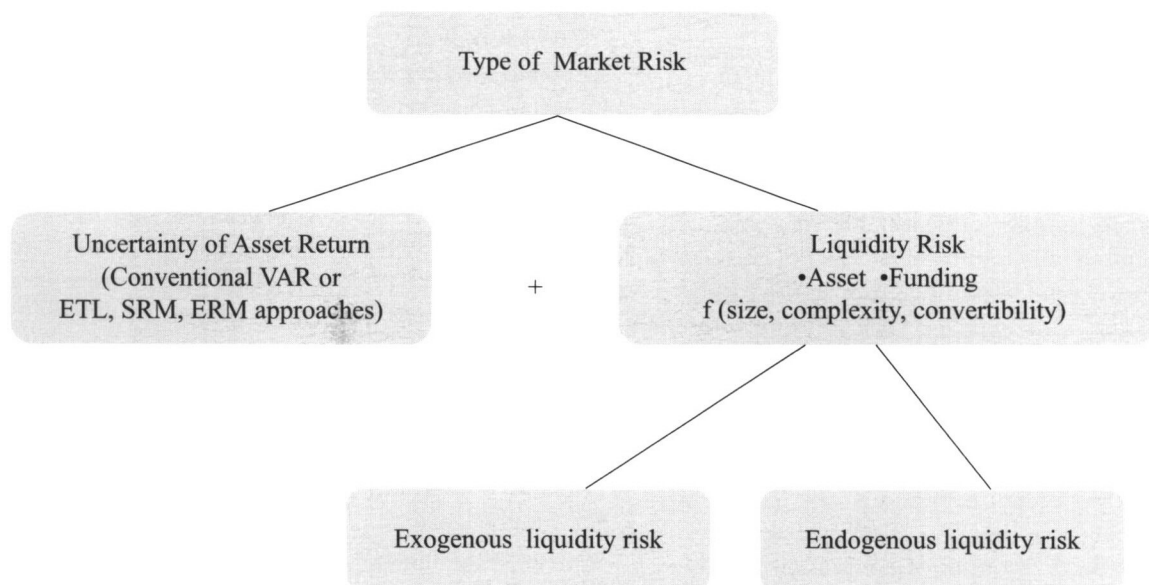
Liquidity risk itself can be categorized in asset risk and funding risk (see Exhibit 1). Asset risk is the risk that an asset cannot be sold or bought at an economical price. Naturally, the bigger the size of the position, the higher the asset risk, as experienced by Metallgesellschaft in 1993 or LTCM in 1998. Also, the higher the complexity of the asset or the lower the convertibility, the higher the liquidity risk. Liquidity risk can be exogenous, relating to the asset in question, not the holder. For example, bonds in, or close to, default typically become very illiquid, regardless of who holds them. Liquidity risk can be endogenous, relating to an entity. For example, a company or a country with low credit rating may experience funding scarcities for new projects, as experienced by many Southeast Asian countries in 1997. Liquidity risk arises from not being able to redeem one’s investment instantaneously at fair price.

A GAME-THEORETIC ILLUSTRATION OF THE VALUE OF LIQUIDITY

Thus far, very little has been done in quantifying liquidity risk (Bhaduri and Kaneshige [2005]). A recent paper (Bhaduri and Whelan [2008]) explores the following one-person game to help illustrate the value of liquidity. Consider a hat with b black balls and w white

EXHIBIT 1

Categorization of Liquidity Risk



balls. At each turn, the player chooses whether to draw out a single ball at random, without replacement. The game ends when the player chooses not to remove any further balls. The player gains \$1 for each white ball drawn, and loses \$1 for each black ball drawn. In a hat with b black balls and w white balls, suppose that the player chooses a white ball, and is left with \$1 plus a hat with b black balls and $w - 1$ white balls. If the player picks a black ball, then he or she is left with $-\$1$ plus a hat with $b - 1$ black balls and w white balls. The probabilities of these two outcomes are, of course, given by the ratios of the numbers of each color to the total number. The decision of whether or not to play is determined by the expected winnings under the two scenarios. If that expectation were less than zero, the player would stop playing.

Mathematically, we can express this as:

$$E(b, w) = \max \left[\frac{w}{b+w} (1 + E(b, w-1)) + \frac{b}{b+w} (-1 + E(b-1, w)), 0 \right]$$

Bhaduri and Whelan demonstrate that liquidity has a definite impact on the value of the game. For instance, a hat with six black balls and four white balls has a positive expected value of 1/15. The reason for the positive value is that the power of liquidity (i.e., being able to stop playing any time) overcomes the negative imbalance of black balls to white balls. The player's advantage of getting to choose to stop picking balls at any time is actually a rather large one, and the reason behind this result. Being able to withdraw from the game at any time in a seamless fashion (i.e., without the action of having an impact on the value of the investment) is analogous to having full liquidity. From a behavioral finance point of view, this example seems to suggest that humans are wired such that they will tend to underestimate the value of liquidity, since it might seem counter-intuitive to play the balls in a hat game for a hat with six black balls and four white balls. This game helps to demonstrate the value of liquidity.

LIQUIDITY HEDGING INSTRUMENTS

An extreme form of liquidity risk is the "lock up risk" that many investors face when putting their money into a hedge fund. Typically, there is a one- to two-year

lock up. There are several instruments, which can be used to eliminate this risk.

Withdrawal Option

Definition. A withdrawal option allows the investor to withdraw his/her locked-up investment at the market price, as seen in Exhibit 2.

Example. An investor has invested \$1,000,000 in a hedge fund. The hedge fund requires a two-year lock up period. The investor wants to eliminate this risk. He/she buys a withdrawal option from J.P. Morgan. This gives him/her the right to transfer his/her hedge fund investment at the market price to the option seller at any time within the next two years. After six months, the investor is not satisfied with the hedge fund return. He/she also believes in further poor performance of the hedge fund and exercises his/her option. A dealer determines the fair market value of his/her investment as \$800,000. J.P. Morgan pays him/her \$800,000 and takes over his/her investment position.

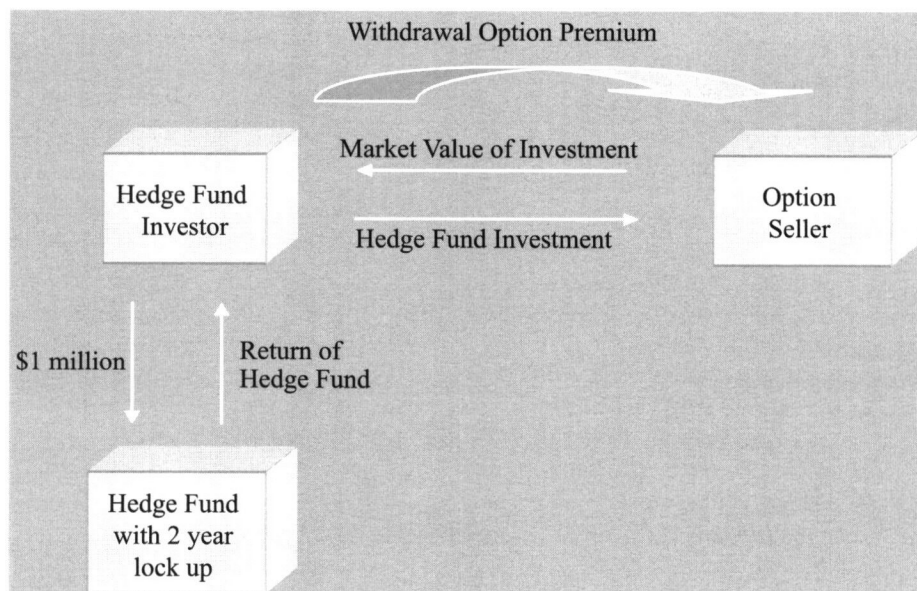
A withdrawal option addresses only the liquidity aspect of a lock up feature. If the investor had purchased a withdrawal option with a strike of his/her original investment of \$1,000,000, this would be identical to a put option on the hedge fund return (see the next sub-section).

A withdrawal option has similar properties to the prepayment options of mortgages in the U.S. In the U.S., typically, the mortgagee has the right to prepay his/her mortgage without a penalty. The premium for this option is built into the mortgage. Mortgagors sometime exercise their right to prepay for non-financial reasons, for example, if they received an inheritance and can afford to repay. Similarly, in a withdrawal option, the investor can withdraw his/her investment if he/she believes the return is unsatisfactory or if he/she is simply unsatisfied with the service.

Pricing. Pricing withdrawal options requires modeling investor withdrawal behavior. Not much research has been done in this area. The withdrawal option gains its value because it allows the buyer to redeem an inferior hedge fund investment. In addition, the withdrawal option allows the investor to realize profits in case the hedge fund return is high. Hence, a withdrawal option has similar characteristics as a long straddle (i.e., buying a call and put with the same strike and same maturity). In a recent study, Derman [2006] analyzes the premium required to invest in a hedge fund with lock ups. Derman finds that, based on empirical data and modeling hedge funds with

EXHIBIT 2

Withdrawal Option



a Markov process, the premium for lock ups approaches 3% per year.

Hedge Fund Return Put Option, Bermuda Style

Definition. A hedge fund return option allows the buyer to sell the hedge fund investment at a strike to the option seller, as seen in Exhibit 3.

Example. An investor has invested \$1,000,000 in a hedge fund with a lock up period of two years. The investor wants to protect himself/herself against poor performance of the hedge fund and liquidity risk. He/she buys a hedge fund return put from an option seller. As a strike, the investor chooses 90%. The option can be Bermuda style, for e.g., with monthly exercise, which matches the return publication frequency of most hedge funds. The option gives the investor the right to exercise the put monthly and receive \$900,000 from the option seller. The option seller will take over the original investment into the hedge fund and, hence, receive the returns.

Formally, the payoff is $\max(900,000 - \text{PV}(\text{hedge fund investment}), 0)$.

Pricing. Standard option valuation techniques can be applied. If Black-Scholes-Merton is used, it is assumed

that the underlying hedge fund return H follows a geometric Brownian motion: For discrete time intervals Δt , we have

$$H_{t+\Delta t} = \mu\Delta t + \sigma\epsilon\sqrt{\Delta t} \quad (1)$$

where μ is the average growth rate of H , σ is the standard deviation of H , and ϵ is a random drawing from a standard normal distribution. Since hedge fund returns are typically quite volatile, H can be modeled as including Poisson jumps:

$$H_{t+\Delta t} = \mu\Delta t + \sigma\epsilon\sqrt{\Delta t} \pm (J-1)dq \quad (2)$$

where J is the $(1 - \text{jump size})$, and

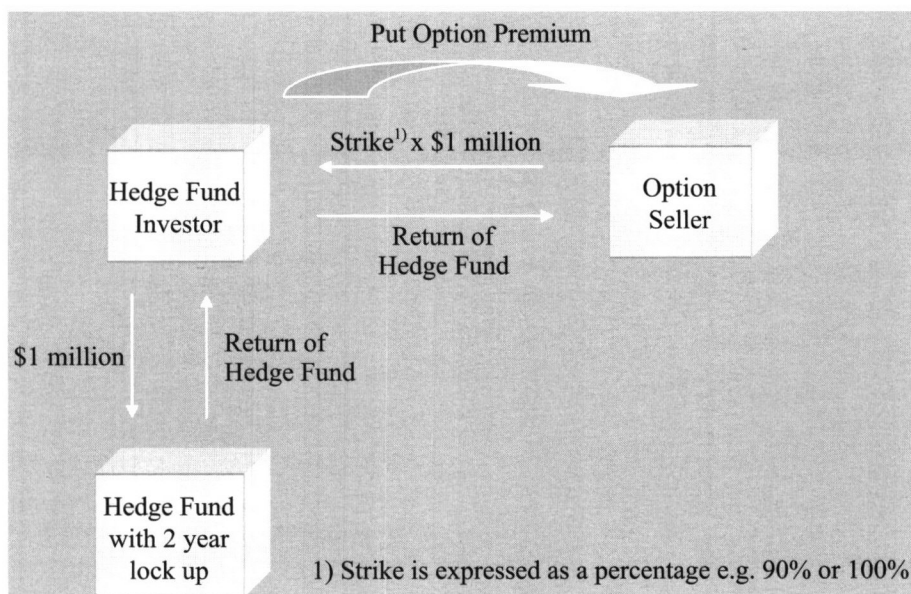
$$dq = \begin{cases} 0 & \text{with prob } 1 - \lambda \, dt \\ 1 & \text{with prob } \lambda \, dt \end{cases}$$

with λ being the jump probability. A simple model explaining the GBM with Poisson jumps can be found at www.dersoft.com/geometricwithjumps.xls.

We use Monte Carlo to simulate multiple outcomes of Equation (1) or (2). We then take the average of the

EXHIBIT 3

Hedge Fund Return Put Option



outcomes of Equations (1) or (2) and take the present value H . The investor will exercise if $(\text{strike} - 1) > H$, hence the payoff is $\max [(\text{strike} - 1) - H, 0]$ where H is the accumulated average hedge fund return since inception of the investment.

Hedge Fund Return Swap

Definition. A hedge fund return swap exchanges the return of a hedge fund into Libor, as seen in Exhibit 4.

Example. An investor has invested \$1,000,000 in a hedge fund with a two-year lock up period. After six months, the investor is unsatisfied with the hedge fund return. He/she also believes the hedge fund will perform badly in the future. He/she can enter into a hedge fund swap, which exchanges his/her hedge fund return into LIBOR (or some other pre-determined rate). The drawback of this approach is that the hedge fund investor cannot immediately withdraw his/her \$1,000,000 investment. He/she is only protected against negative hedge fund returns.

Pricing. A hedge fund return swap can be priced using standard swap evaluation techniques: we equate the PVs of the expected cash flows of each leg and solve for the fair swap rate s :

$$s \text{ PV E}(H) = \text{PV E}(\text{LIBOR})$$

Hence

$$s = \frac{\text{PV E}(\text{LIBOR})}{\text{PV E}(H)} \quad (3)$$

where PV stands for present value, E for expected value, and H is again our hedge fund return. To model H , we use the "hedge fund curve," i.e., the annual return curve of the particular hedge fund. This has to be estimated by the trader. A model that values hedge fund return swaps can be found at www.dersoft.com/hedgefundreturnswaps.xls. The hedge fund return swap can also be made optional.

Hedge Fund Return Swaption

Definition. A hedge fund return swap option allows an investor to swap his hedge fund return into Libor, as seen in Exhibit 5.

Example. An investor has invested \$1,000,000 in a hedge fund with a two-year lock up period. He/she wants to protect himself/herself against poor hedge fund performance and, at the same time, participate if the hedge fund does well. In this case, the investor pays a premium and has the right to enter into the swap. Similarly to the hedge fund return swap, a hedge fund return option is effectively an insurance against poor hedge fund returns.

EXHIBIT 4

Hedge Fund Return Swap

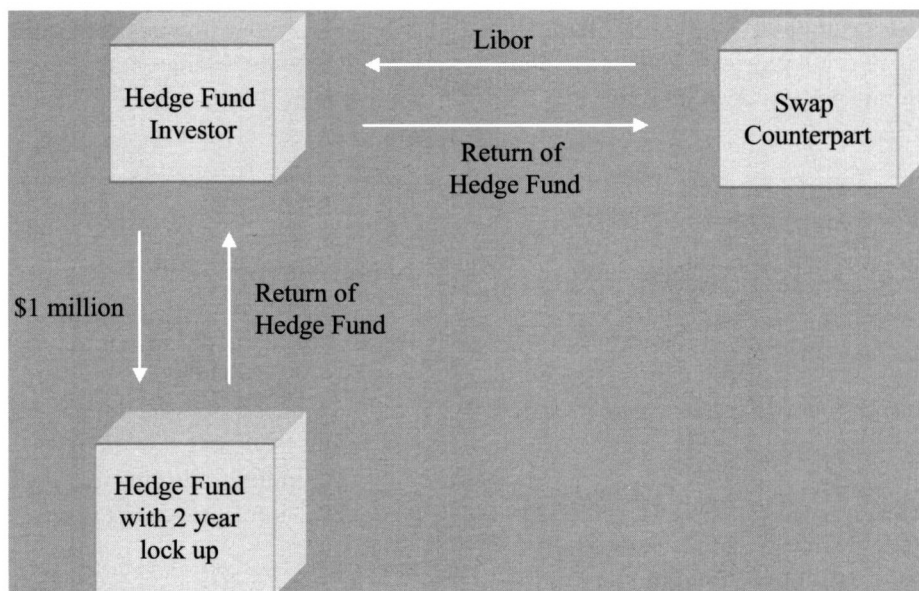
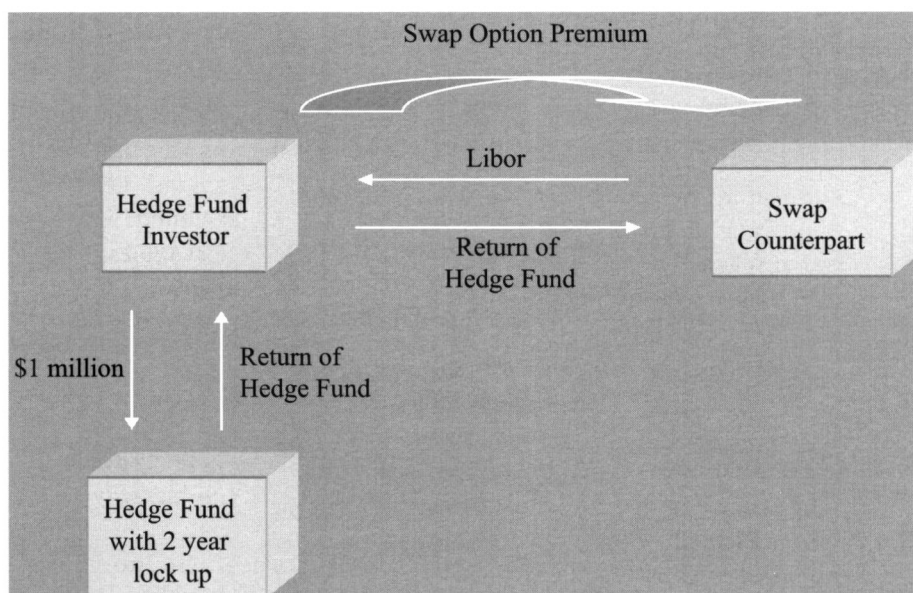


EXHIBIT 5

Hedge Fund Return Swaption



The difference to the hedge fund return swap is simply that the investor will participate in a strong hedge fund return. If the hedge fund does well, the investor will not exercise his/her swap option and receive the strong return.

For this advantage, the investor will pay a premium. The drawback of this instrument is, as in the hedge fund return swap, and unlike the withdrawal option, that the investor

cannot withdraw his/her investment, but has to wait until the end of the lock-up period.

Pricing. Standard swaption valuation techniques, such as Black 76, can be applied. The model requires a hedge fund return curve (with respect to time) as an input. A program can be found at www.dersoft.com/hedgefund/returnswapoption.xls.

Liquidity Option

Definition. In a liquidity option, the investor can withdraw his/her investment in a publicly traded asset at the market price if the liquidity of the asset is low, as seen in Exhibit 6. (The only difference to the withdrawal option is that the asset here is publicly traded. Hence, we use the property that liquidity is easily quantifiable).

Example. An investor has invested \$1,000,000 in a Mexican bond. He/she wants to protect himself/herself against low liquidity. He/she buys a liquidity option from an option seller, say, J.P. Morgan. This gives him/her the right to sell the Mexican bond to J.P. Morgan at the market price, in case liquidity is low. The liquidity is measured in trading volume. If the trading volume is lower than a pre-specified level on more than two (or any specified number of) consecutive days, the investor may sell the

Mexican bond to J.P. Morgan at the market price. The market price is determined by a dealer poll.

Liquidity can also be measured in widths of bid-ask spread. However, this is more difficult to quantify than trading volume. Hence, trading volume seems to be the more practical measure of liquidity than widths of bid-ask spread.

Pricing. A liquidity option is not very expensive. The seller of a liquidity option faces a loss of half the bid-offer spread (BOS), 0.5 BOS, when he/she liquidates the position (since he/she received the asset at the mid-market price and can sell it at the bid). A liquidity option can be priced by modeling the BOS. Again, we could use a geometric Brownian motion, as in the hedge fund return put option, where μ is the average growth rate of the BOS and σ is the volatility of BOS.

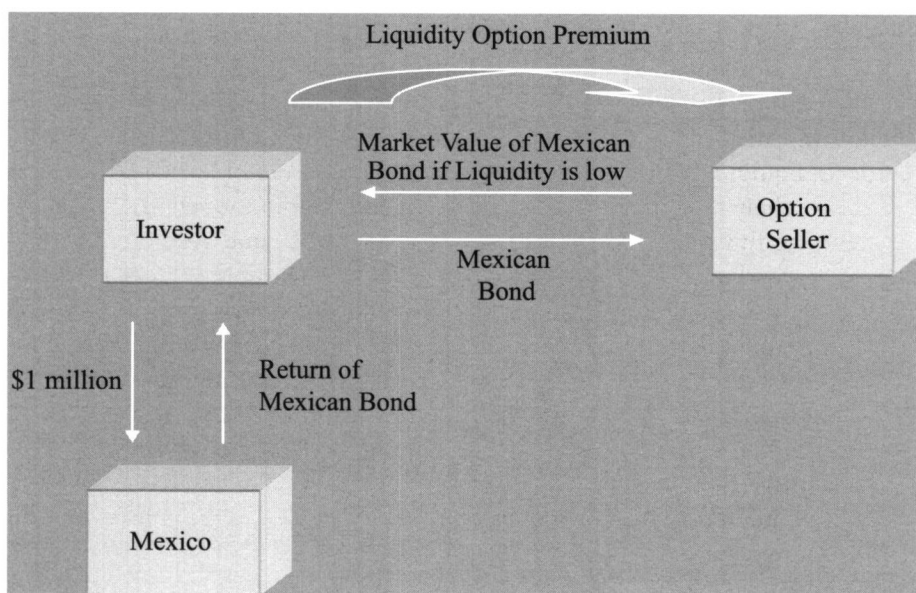
Depending on empirical results, we can include a mean reversion factor as in the CIR (Cox Ingersoll Ross) model:

$$\Delta \text{BOS}_{t+\Delta t} = a(b - \text{BOS}_t)\Delta t + \sigma\sqrt{\text{BOS}_t}\varepsilon\sqrt{\Delta t} \quad (4)$$

where b is the long-term mean of the BOS and “ a ” is the mean reversion rate. The higher “ a ,” the stronger the mean reversion.

EXHIBIT 6

Liquidity Option



The CIR model also seems a good choice for modeling BOS spreads, since by construction, the BOS in (4) is positive. BOS spreads suddenly widen in case of a downgrade or default. Hence, we should again add Poisson jumps. Equation (4) then becomes

$$\Delta \text{BOS}_{t+\Delta t} = a(b - \text{BOS}_t) \Delta t + \sigma \sqrt{\text{BOS}_t} \varepsilon \sqrt{\Delta t} \pm (J-1)dq \quad (5)$$

where J and dq are defined as in Equation (2). We use Monte Carlo to sample many path outcomes of Equation (4) or (5). We average the outcomes and derive the value of the liquidity option as the present value of 0.5 BOS, where BOS is the derived average.

In this analysis, we have assumed that a bid-offer spread exists and can be modeled. In extreme cases, as the LTCM/Russian bond crisis, the market was temporarily illiquid and, hence, there were no bidders. Also, in this extreme case, the liquidity option protects the liquidity option buyer. He/she will give the bonds to the liquidity option seller at the market price that the dealer poll has determined. The liquidity option seller now owns the totally illiquid asset. If the seller of a liquidity option assumes extremely low liquidity will occur, the jump component parameter J and frequency λ in Equation (5) should be high.

Motivations, Applications, and Limitations

The above example is just one of a myriad of applications available to investors of all types. A typical buyer of liquidity would be any investor who is long the underlying, which may include pension funds, endowments, family offices, insurance companies, banks, and funds of funds who wish to mitigate liquidity risk and/or hedge fund return risk. In essence, their potential investment universe has been broadened to funds that, while from a pure portfolio management standpoint fit in well on a risk/return and diversification basis, previously lacked the liquidity component necessary to fulfill the original mandate. On the other side, it allows a speculator to, in essence, protect his/her hedge fund investment should he/she have a negative view on the fund. With the convergence of hedge funds and private equity (Bhaduri [2007]) into illiquid strategies, the use of liquidity derivatives will be attractive. The ability to hedge liquidity risk should increase the buyers of hedge funds.

Typical sellers of liquidity may include all of the above institutional investors who wish to create an overlay position, speculate on the underlying fund, or simply receive the swap fees. These counterparties may be bullish on the fund and see the potential exposure to the fund as a positive. In the meantime, they receive a fee for selling the option that compensates them for the uncertainty of the timing of the swap. This allows some companies that wish to have a short-term synthetic exposure to the hedge fund a predetermined time horizon. Further, if triggered, the counterparty has access to a fund that is closed to new investors with a predetermined period.

Liquidity derivatives could be structured either way, such that the notional net asset value at the time of exercise is returned to the buyer, or else the buyer receives some pre-determined rate based on the value at the time of exercise and the notional amount is returned at the end of the swap's life. For example, suppose a pension fund has invested \$10 million in a hedge fund and buys a liquidity swaption to gain liquidity. Six months after investing in the hedge fund, the pension fund decides to deploy its money elsewhere as a certain opportunity has arisen. The pension fund invokes its liquidity swaption. At the time of exercising its swaption, the value of the pension fund's investment in the hedge fund has grown to \$10.6 million. Consequently, if the liquidity derivative were structured to return the notional to the buyer, then the pension fund would receive \$10.6 million from the seller of the liquidity derivative. The pension fund would also be responsible for paying the monthly return of the hedge fund to the seller; the seller would receive the value of the notional amount invested in the hedge fund at the conclusion of the swap's life. Alternatively, the swaption might be structured such that the pension fund receives a certain pre-determined rate, say LIBOR, on the \$10.6 million while it has to pay the return of the hedge fund to the seller. At the conclusion of the swaps, the pension fund would receive \$10.6 million, and the seller would get the notional of the investment's value at the conclusion of these swaps. Either way, the pension fund gains liquidity and has successfully mitigated its liquidity risk. The pension fund has cost certainty for this protection of improved liquidity. The seller of the liquidity derivative is left exposed to the underlying instrument. The seller entered into this agreement presumably because it viewed the premium that it charged to be worth the risk.

The players of liquidity derivatives can be grouped into the three classes: hedgers for risk management purposes, speculators, and arbitrageurs. Some hedge funds might incorporate these instruments into their trading and business strategy. One can imagine that exotic types of synthetic liquidity derivatives will develop, perhaps even on hedge fund indices. Some players, with longer time horizons, may choose to be sellers of liquidity derivatives (see Exhibit 7).

A limitation is that the pricing of liquidity derivatives will involve a good deal of qualitative analysis. Proper due diligence of the underlying investment (whether it is a hedge fund, fund of hedge funds, private equity fund, or some other investment vehicle) will be critical in assessing the "right" price. It would not be prudent to solely use quantitative methods in assessing the risk. Potentially, the pricing of liquidity derivatives will also use the ratings on hedge funds issued by agencies such as Moody's or Standard & Poor's. Funds of hedge funds and funds of private equity funds often use a blend of quantitative and qualitative due diligence in their investment process and, as a result, what one fund of funds might find ideal on a risk-adjusted basis, another might not. The underlying fund's expected risk-return profile will be a driving force of the price of the liquidity derivative, but the uncertainty and difficulty of determining an accurate, forward-looking risk-return profile for the hedge fund will create some challenges. There will be certain known factors, such as the length

of time of the derivative's life, and the underlying fund's redemption terms, that will also be used in determining the price of the liquidity derivative. For those hedge funds that have a penalty fee for early redemption, this too will be an obvious factor in the price of a liquidity derivative; indeed, the fee will be an upper bound on the price. The nuances of the terms of the liquidity derivative will, obviously, be very important. The language needs to be precise and comprehensive in order to avoid dispute—consequently legal risk may be present. Counterparty risk, as in all swaps, exists for both the buyer and seller of the liquidity derivative. Counter-party risk (from both sides) is another element of a pricing model of liquidity derivatives.

The primary purpose of *liquidity* derivatives is to mitigate *liquidity* risk; thus, these instruments improve the liquidity of an investment and, for this improvement, the buyer is paying a fee. It does not act as an insurance policy in the sense that the hedge fund investor is able to redeem his investment if the fund has a blow-up. If a hedge fund has a material event, such as a large drawdown or key executives leaving, it could ignite a flight to quality for the investors of the hedge fund. This potentially leaves the hedge fund vulnerable for further negative returns as it unwinds its book in fire sale fashion; holders of liquidity derivatives will naturally exercise, not for liquidity purposes, but to simply redeem an investment turned sour, and sellers of liquidity derivatives would have to make the price of the premium substantial to help

EXHIBIT 7

Players of Liquidity Derivatives

	Advantages	Disadvantages
Investor	Mitigating liquidity risk Broaden potential investments Avoid early redemption fees, if any Customized	Fees paid Counterparty Risk Legal Risk
Counterparty	Potential synthetic hedge fund exposure with stated term Potential access to closed funds Fees received Avoid early redemption charges for short-term investment Leverage	Short the option Legal Risk Counterparty Risk
Hedge Fund	Increase client base Lower redemptions Instrument to trade (either for hedging or speculation)	Higher potential turnover

protect themselves. To avoid this scenario, the terms of the liquidity swaption might include the provision that the option may only be exercised if the fund does not experience a drawdown larger than a certain specified number. Obviously, such clauses will materially affect the pricing of the derivative. This clause would lower the risk for the seller and, therefore, lower the cost of the liquidity derivative, making it more accessible. If the buyer of a liquidity derivative wants the added protection of being able to exit after a large drawdown, then he/she will have to pay appropriately for that upgrade. The terms of the derivative should include the provision that if a hedge fund were to shut down, then the liquidity swaption would terminate, thus protecting the buyer of the liquidity derivative from a double ignominy. The exact terms and subtle nuances of the contracts may help fuel further research in areas of operational risk, game theory, and derivatives pricing.

Another limitation of these instruments is, ironically, liquidity itself. More precisely, will the market demand and market supply be sufficient so that the uses of these instruments are viable? Ideally, there would be a market maker: one that is active in trying to grow this market and match up investors. Even if a potential investor is interested in a liquidity instrument, there is a natural time lag before such instruments gain traction and are accepted. As stated earlier, pricing of these instruments will not be easy, but if many players decide to trade these instruments, then the market will also play a role in determining the price.

CONCLUSION

Liquidity risk is a key concern among institutional investors. This article introduced five instruments that directly hedge against liquidity risk and/or return risk. Applications and elementary pricing algorithms are provided. The possibility of some of the uses of liquidity derivatives was explored, but there are many more possibilities. A hedge fund may wish to enter a synthetic liquidity derivative for hedging purposes. A pension fund that is new to investing in the alternatives space may choose to start its investment using a liquidity derivative. Limitations are pointed out, such as the complexities of pricing these instruments, and the challenge of a new instrument to attract enough players so that the market is sustainable and meaningful.

Liquidity derivatives offer a fertile ground for further research. Pricing liquidity derivatives, applying liquidity derivatives to other illiquid investments (such as private equity, infrastructure, and real estate), synthetic liquidity derivatives—are all areas for potential investigation. In addition, while it is well known that psychology and the human element have tangible effects on the capital markets (Nofsinger [2005]), research on behavioral finance applied to liquidity might yield useful insights.

In his classic book, Bernstein [1996] argued that the notion of bringing risk under control is one of the central ideas that distinguish modern times from the more distant past. Indeed, over the past two decades, the financial community has been producing a steady stream of very useful instruments such as interest rate derivatives, currency options, weather derivatives, credit default swaps, and real estate derivatives in order to help manage risk. The rapid growth and development of the credit derivatives market (Meissner [2005]) helps to illustrate the market's appetite for creative financial tools that may be used for a variety of reasons (hedging, trading strategies, speculation). Similar to the growth of credit derivatives, there is no reason why there should not be the creation of several exotic liquidity derivatives, including a synthetic market. The underlying need not be restricted to hedge funds and fund of hedge funds, but can span any instrument that has illiquidity, including private equity, real estate, or mortgage-backed securities. Pricing of this derivative will provide mathematicians and financial practitioners food for further research and, due to the importance of liquidity, these instruments will become essential for the financial community. Liquidity derivatives continue the theme of isolation of risk and the redistribution of that risk to willing parties.

ENDNOTES

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¹Vanessa Drucker. "Before You Leap." *Bloomberg Magazine*, October 2005, pp. 55.

²Hennessee Hedge Funds Survey, May 2005.

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RISK MANAGEMENT

HEDGING LIQUIDITY RISK: *Potential Solutions for Hedge Funds* 80

RANJAN BHADURI, GUNTER MEISSNER AND JAMES YOUNG

The financial markets have successfully established hedging instruments to protect against market risk, interest rate risk, currency risk, commodity risk and credit risk. The classic work in option-pricing by Black & Scholes [1973], and Merton [1973] helped mitigate equity risk through the prudent use of equity options. In the past three decades, derivatives in interest rates, foreign exchange, weather, and real estate have all grown in popularity. Each of these instruments allows for the isolation of an element of risk, and the transfer of this risk to a willing market participant. Recently introduced derivatives protect against adverse weather and real estate movement. Liquidity risk however, although well known, is not directly hedged, since liquidity derivatives do not yet exist. This article introduces several liquidity derivatives, which can protect against liquidity and/or return risk. Applications and elementary pricing algorithms are provided. Proposals of areas of further research are also suggested.

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LUDWIG CHINCARINI

The speculative activities of hedge funds have generated considerable interest among market agents and regulatory institutions. In September 2006, the activities of Amaranth Advisors, a large-sized Connecticut hedge fund in the natural gas market resulted in serious losses. By September 21,

2006, Amaranth had lost roughly \$4.35B over a 3-week period or one half of its assets due to its activities in natural gas futures and options in September. Shortly thereafter, Amaranth fund was liquidated. This article presents a brief investigation of the possible causes behind this spectacular hedge fund failure and draws lessons by assessing Amaranth's trading activities within a standard risk management framework. Even by conservative measures, Amaranth was engaging in highly risky trades which in addition to high levels of market risk involved significant exposure to liquidity risk—a risk factor that is seemingly difficult to manage.

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